

REPORT DOCUMENTATION PAGE

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

21 separate items enclosed

2308119B

MEMORANDUM FOR PR (In-House Publication)

FROM: PROI (TI) (STINFO)

24 January 2000

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-TP-2000-015**
Levine, J., Wysong, I., "Coordinated Development of DSMC Plume & Contamination Models"

AFOSR Meeting (plus Russian Scientists) (Deadline: 25 Jan 2000)

(Statement A)

1. This request has been reviewed by the Foreign Disclosure Office for: a.) appropriateness of distribution statement, b.) military/national critical technology, c.) export controls or distribution restrictions, d.) appropriateness for release to a foreign nation, and e.) technical sensitivity and/or economic sensitivity.

Comments: _____

Signature _____ Date _____

2. This request has been reviewed by the Public Affairs Office for: a.) appropriateness for public release and/or b) possible higher headquarters review.

Comments: _____

Signature _____ Date _____

3. This request has been reviewed by the STINFO for: a.) changes if approved as amended, b.) appropriateness of distribution statement, c.) military/national critical technology, d.) economic sensitivity, e.) parallel review completed if required, and f.) format and completion of meeting clearance form if required

Comments: _____

Signature _____ Date _____

4. This request has been reviewed by PR for: a.) technical accuracy, b.) appropriateness for audience, c.) appropriateness of distribution statement, d.) technical sensitivity and economic sensitivity, e.) military/national critical technology, and f.) data rights and patentability

Comments: _____

APPROVED/APPROVED AS AMENDED/DISAPPROVED

ROBERT C. CORLEY
Senior Scientist (Propulsion)
Propulsion Directorate

(Date)

FDO - 100 + 1000 - 1000 - are the
sleekers and discussions material received
PRSA.

Presentations - E plant &
consider this my review. C.O. Bile
OK for public release. (FDO) 1.24.00

Coordinated Development, Validation and Transition of DSMC-based Plume and Contamination Models

Jay Levine and Ingrid Wysong

AFRL/PRSA

Edwards AFB, CA

27 January, 2000

Air Force Office of Scientific Research



Outline / Introduction

Still working on this...





DSMC Related Basic Research: Coordinated Laboratory/University/International Program

AFOSR/NA

Dr. Mitat Birkan

George Washington U.

Levin
AFOSR, ARO, BMDO

MirEx, Shuttle data
Quantum Chemistry, Spacecraft glow
surface chemistry
Plume radiation modeling

University Michigan

Boyd
AFOSR, ARO

DSMC modeling -- plumes, EP,
PIC hybrid, chemistry models,
radiation, particulates

ITAM, Russia

Ivanov
European Space Agency,
Russian Academy of Science
EOARD/BMDO

DSMC code development and research
Advanced models, validation,
Hypersonics, Contamination

AFRL/PRSA

Wysong
AFOSR

Collision and Chemistry models
Experimental Validation
Micropulsion, Microfluidics

NASA

Moss, Lumpkin
Planetary Reentry
Space Station Contamination
Hypersonics

AFRL/VSSBS

Dressler, Murad
AFOSR/NL

Reaction cross sections,
Shuttle DSMC simulation tool

AFRL/PRSA, USC

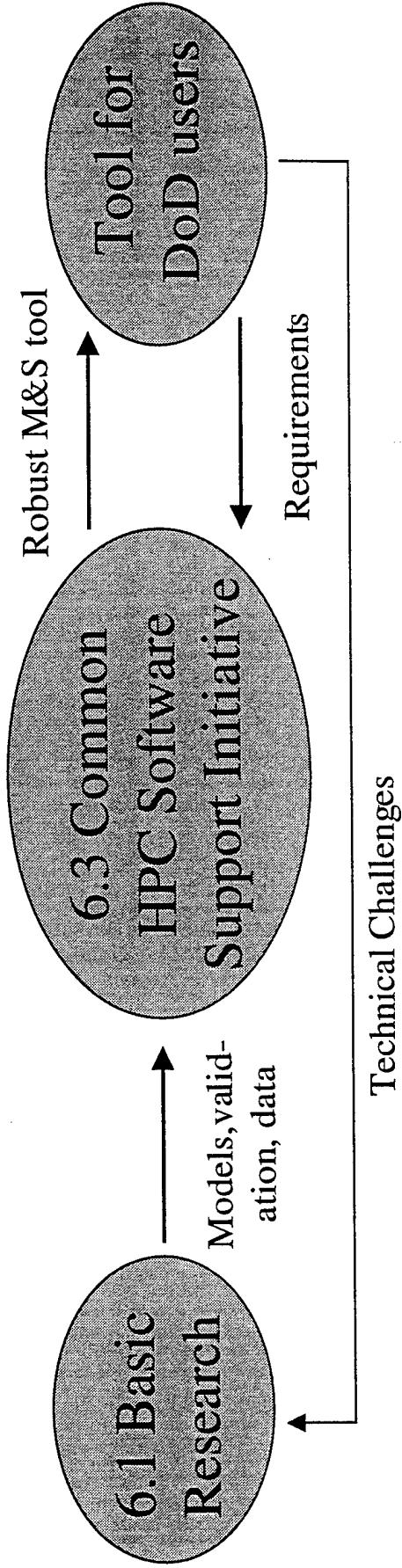
Ketsdever, Muntz
AFOSR, ARO, AFRL

CHAFF Contamination
Measurement Facility
Validation Data

DSMC Simulation Tool: Applications, Payoffs

DoD Application	Scientific/Technical Challenges	Payoff
High Altitude Rocket Plume Radiation – BMDO, AF, Navy	Chemically reacting flow, trace species, spatial resolution	National Defense
Plume / Spacecraft Interactions – AF TechSat21	Surface collisions, complex 3D geometries	Increased orbit lifetime, decreased sensor, array degradation
MEMS – AF, DARPA	Surface dominated effects, unsteady highly viscous flows	Optimized microsatellite propulsion systems, embedded sensors
Hypersonic Flight, Re-entry – AF HyTech, Military Aerospace Vehicle	Shock layer, trace species chemistry, aerodynamics	Improved aerodynamic performance, vehicle/propulsion integration

DOD CHSSI Program: An Opportunity for Accelerated Technology Transfer



CHSSI Project: \$1.5 million, 3 years, AFRL, NRL, outside experts: ITAM, Boyd, Bird

Leverages the extensive 6.1 research from AFOSR

Leverages SMILE code (ITAM) for test-bed

First DSMC code for non-expert users tailored to DoD applications

AFRL/PRSA is a key player in all three facets of this effort; our ongoing research and application work facilitates coordination and technology transition

All three facets benefit from substantial international participation

AFRL/PRSSA DSMC Research and Transition Plumes: Wyson, Wadsworth

Twice awarded AFOSR Star Team for excellence in basic research

DSMC Research: -- Chemical models, Validation (Boyd, Ivanov, Levin, Rich, Dressler)

DSMC Transition: CHSSI Project (NRL, Ivanov, Boyd, Bird)

DSMC Transition: Cooperation with Plume Phenomenology BMDO group -- transition research results to users. Join realistic engine/nozzle CFD results to DSMC plume simulations (Levine, Smith)

MirEx Steering Group: Potential DSMC validation; AFRL input and cooperation (AEDC, Tsniimash, Levin)

Chemical Kinetics: Vaghjiani, Alfano -- experimental research on combustion, plume radiation kinetic mechanisms and rates

DSMC Chemistry Model Research

Working on this...

Example of results

On-going: Current work with AFRL/VSSBS
uses recently measured dissociation cross
sections for more extensive validation

AFRL/PRSA DSMC Research and Transition *Micropropulsion, Microfluidics: Ketsdever, Wadsworth*

Free Molecule Micro-Resistojet (FMMR) -- basic research
(surface models) and transition (MicroSat propulsion flight test)
(USC, NASA JPL)

Application areas: Plume/Spacecraft Interaction for
Constellations (TechSat21), MEMS

Micronozzle flow -- effect of boundary layer, important for
performance, spacecraft interaction (ITAM)

Microvalves -- key for micropulsion systems (NASA JPL)



6.1 Transition to 6.2/6.3 Free Molecule Micro-Resistojet (FMMR)

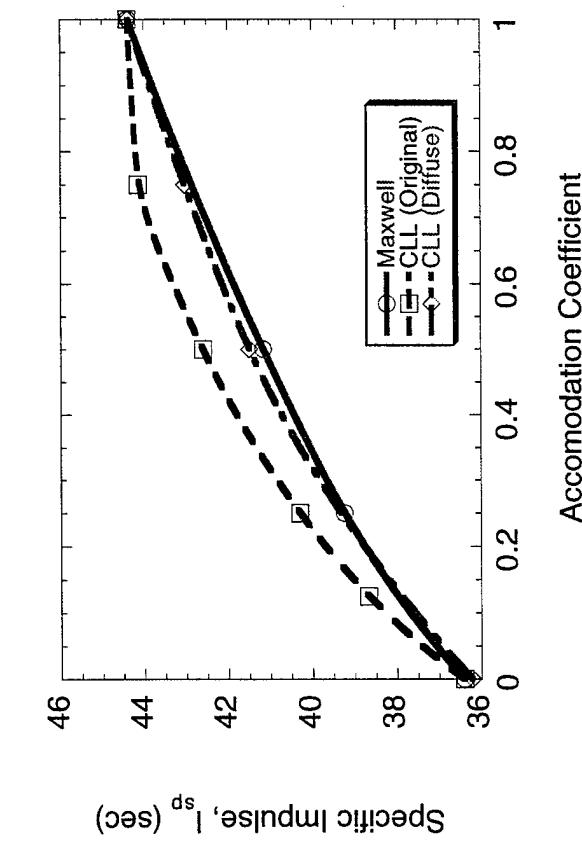
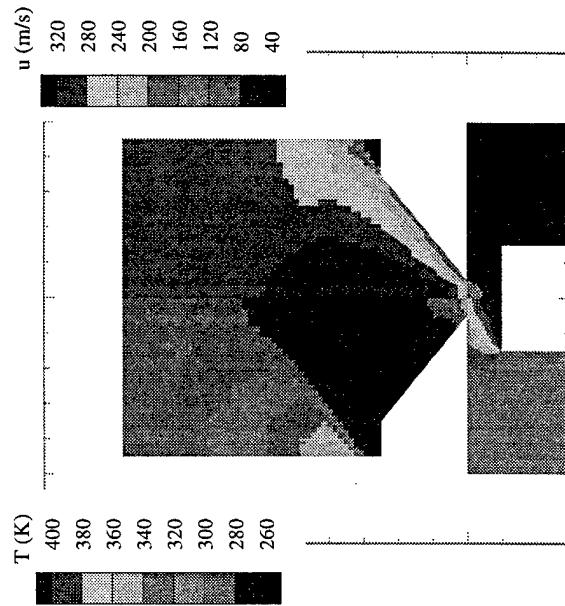
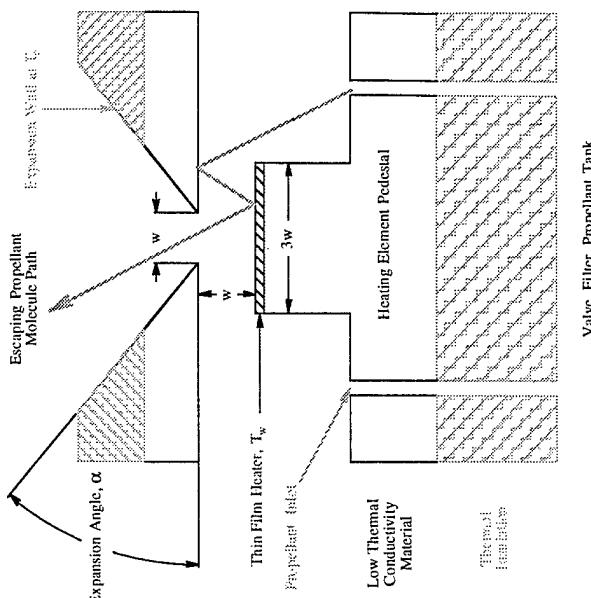
– AFRL Patent Pending

MEMS Fabricated Micropropulsion System

– Low Cost, Robust MEMS Structure

Transition Effort Builds on 6.1 Basic Research
Free Launch on AFOSR/DARPA University
Microsat Flight Experiment (ASU)

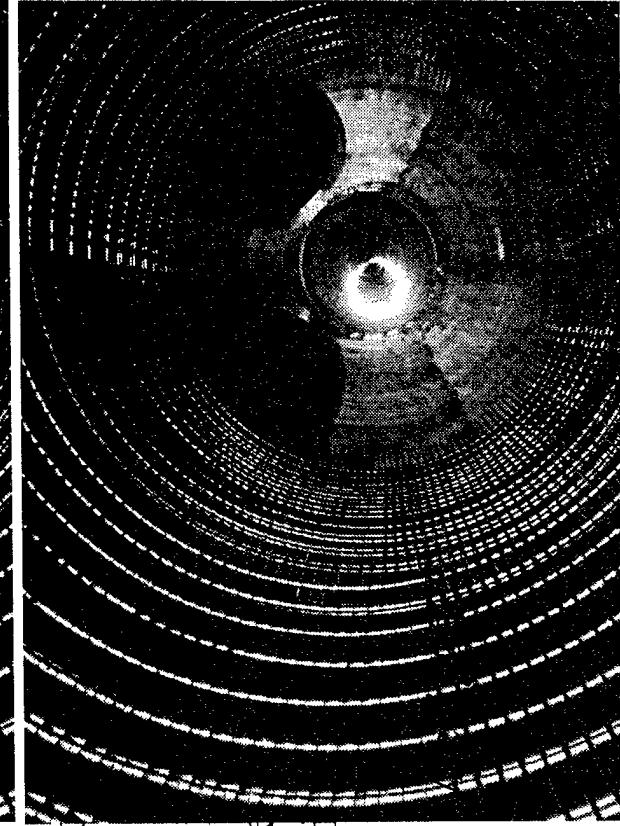
Partners: JPL, ASU, USC



Accommodation Coefficient

AFRL/PRSA DSMC Research and Transition *Spacecraft Interaction: Key*

CHAFF Collaborative High Altitude F
AFRL/PRSA, USC
AFOSR DURIP and ARO fund
A unique, world-class space simulation
assess thruster/Spacecraft interactions



- Apply DSMC code to contamination prediction
- Improve surface physics models
- Validate results: lab measurements / space e
- Identify chamber effects on contamination me
- Transition to microspacecraft cluster contam
potential - unknown effects
- Coordinated expt and modeling, AFRL/PRR,

Collaborative Research Opportunities

On-going projects have demonstrated the feasibility and value of US/Russian collaborations in:

- Combined Ground test data, Modeling and Simulation, Flight expt. Data

Previous Case: ESEX EP Flight Expt. -- AFOSR-supported research allowed DSMC simulation for pre-flight prediction of thruster contamination measurement

Nov. 4 workshop organized by Dr. Birkan gathered input from experts

Proposed Areas

Hall Effect Thruster:

- Flight data -- Tsniimash, AEDC
- Ground data -- Michigan (Gallimore), AFRL/PRR, CHAFF, AEDC, Tsniimash
- Simulation -- Michigan (Boyd), AFRL/VS

Pulsed Plasma Thruster:

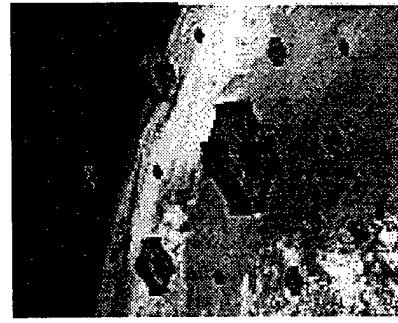
- Flight data -- TechSat21 AFRL/VS, AFRL/PRR
- Simulation -- Michigan (Boyd), GWU (Levin)
- Ground data -- CHAFF (AFRL/PRSA, USC), AFRL/PRR

Chemical Thruster:

- Simulation: ITAM, AFRL/PRSA, GWU, Michigan (Boyd), AFRL/VS
- Ground data -- CHAFF (AFRL/PRSA, USC)

Micropropulsion:

- Simulation -- ITAM, AFRL/PRSA
- Ground, Flight data -- TechSat21, AFRL/PRR



High Altitude Plume and Contamination Program

- High quality, productive basic research program
- Strong focus on technology transfer
- Effective collaboration among Government agencies, University, International partners
- Initiative possibilities being explored for further cost-effective data and simulation effort on plume/spacecraft interactions